HP Turbine Dense Pack Modifications
Operating Options and Economic and Environmental Analysis

		Unit Operation			Economics				Environmental			
Option	Description	Station Max Gross Load	Station Net Heat Rate (BTU/KWH)	Station Fuel Consumption (TONS/YEAR)	Total Capital Cost	Benefit Per Year	Payback Period (Years)	Benefit/Cost Ratio	NOx Emissions per Year (Tons)	SO2 Emissions per Year (Tons)	Environmental Assesment	Comments
	Current Operation	1750 MW	9500	5,268,249	NA	NA	NA	NA	26109	2984	Current Emissions limits are 0.5 lbs/MBTU of NOx and 0.15 Lbs/MBTU of SO2. Both or rolling 30 day average basis.	Current NOx emissions rate is 0.42 lbs/MBTU and SO2 is 0.048 lbs/MBTU
1	Maintain the same historical maximum load with improved heat rate.	⇔ Same	⇩ -214	⇩ -118,536	$9,400,000	$4,267,282	0.96	11.67	⇩ -587	⇩ -67	Operating in this manner should not trigger a New Source Review (NSR) or Prevention of Significant Deterioration (PSD) review.	Assumes no change in NOx and SO2 emissions rate.
2	Maintain the same historical steam flow and increase turbine/generator output. (Note 7)	⇧ 40 MW	⇩ -214	⇔ Same	$9,600,000	$15,137,280	0.28	39.46	⇔ Same	⇔ Same	Since Nox and SO2 emissions are unchanged, increasing the load should not mandate a NSR or PSD review.	Assumes no change in NOx and SO2 emissions rate.
3	Install additional plant improvements to increase boiler and other systems capacity. No new NOx control equipment	⇧ 100 MW	⇩ -214	⇧ 310,224	$21,400,000	$37,843,200	0.43	26.33	⇧ 2854	⇩ -680	If we agree to lower our current Nox emissions limit to 0.47 Lbs/MBTU, we might be able to get this approved as a "synthetic minor" change.	Assumes NOx emissions rate increases to 0.44 lbs/MBTU. SO2 emissions will lower to 0.035 *Lbs/MBTU. (Note 6)*
4	Install additional plant improvements to increase boiler and other systems capacity. Install moderate NOx reduction equipment (ie: SNCR).	⇧ 100 MW	⇩ -214	⇧ 310,224	$36,400,000	$35,784,705	0.87	12.89	⇩ -6362	⇩ -680	If some decrease in Nox emissions is required, this might be the least costly alternative. There is a strong possibility that this would be "best available control technology" which would get us beyond 2007.	NOx emissions will lower to 0.3 Lbs/MBTU and SO2 emissions will lower to 0.035 Lbs/MBTU
5	*Install additional plant improvements to* increase boiler and other systems capacity., Install aggresive NOx reduction equipment (ie: SCR)	⇧ 100 MW	⇩ -214	⇧ 310,224	$191,400,000	$32,639,250	1.49	7.54	⇩ -16236	⇩ -680	SCR's should only be installed if the currently proposed national limit of 0.15 lbs/MBTU by 2007 is actually placed into law by the EPA.	NOx emissions will lower to 0.15 Lbs/MBTU and SO2 emissions will lower to 0.035 Lbs/MBTU

Item	***General Assumptions***	
1	Present Value Annuity Factor (P/A, 6.35 %, 20 years):	11.2
2	Hours of equivalent operation/year (8760X 0.9 Cap. Factor):	7884
3	Cost of Fuel ($/Ton):	$36
4	Cost of replacement energy ($/MWH)	$48
5	Avoided maintenance cost for the station (Note 1):	$5,304,000
6	High pressure turbine section retrofit:	$9,400,000
7	Cost of additional plant improvements (Note 2)	$12,000,000
8	Cost of moderate NOx control equipment:	$15,000,000
9	Cost of aggressive NOx control equipment:	$170,000,000
10	Operating cost per year for SNCR:	$2,058,495
11	Operating cost per year for SCR:	$5,203,950
12	Coal BTU/LB	11,800
13	Urea (SNCR Reagent) Utilization per Ton NOx removed (Tons)	1
14	Ammonia (SCR Reagent) Utilization per Ton of NOx removed (Tons)	0.37
15	Cost of Urea per Ton	$300
16	Cost of Ammonia per Ton	$300

Analysis for Option 1	
Turbine Efficiency Increase (guaranteed by supplier) =	2.25%
Boiler Heat Input Reduction = Proportional to Turbine Efficiency Increase =	2.25%
Net Heat Rate Reduction = 2.25%(9500 BTU/KWH) =BTU/KWH	214
Reduced Fuel = (Heat Rate Reduction)(Station Net Load)(Equiv.Hrs)/(Coal BTU/Lb)(2000 Lbs/Ton) = (Tons)	118,536
Benefit per Year = (Reduced Fuel)(Cost of Fuel) = $	$4,267,282
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.96
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs - Avoided Costs) =	11.67

Analysis for Option 3	
Benefit per Year = (Increased Generation)(Equiv. Hrs.) (Cost of Replacement Energy) = $	$37,843,200
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.43
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs - Avoided Costs) =	26.33
Increased Fuel = (Decreased Heat Rate)(Increaed Net Load)(Equiv.Hrs)/(Coal BTU/Lb)(2000 Lbs/Ton) = (Tons)	310,224

Analysis for Option 2	
Benefit per Year = (Increased Generation)(Equiv. Hrs.) (Cost of Replacement Energy) = $	$15,137,280
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.28
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs - Avoided Costs) =	39.46

Analysis for Option 4	
Benefit per Year = (Increased Generation)(Equiv. Hrs.) (Cost of Replacement Energy) - Operating Cost/Year = $	$35,784,705
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.87
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs-Avoided Costs) =	12.89

Analysis for Option 5 (See Note 3)	
Benefit per Year = (Increased Generation)(Equiv. Hrs.) (Cost of Replacement Energy) - Operating Cost = $	$32,639,250
Payback Period = (Capital Costs + Interest for NOx Control- Avoided Costs) /Benefit per Year = Years	1.49
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Cost for Upgrade + Interest for NOx Control - Avoided Costs) =	7.54

Notes

Note 1 - Avoided maintenance cost equals the normal overhaul cost for the turbine HP section plus the avoided outage extension of 3 days to refurbish the HP nozzle block.

Note 2 - Cost of additional plant improvements is the projects necessary to increase the capacity of all other plant systems to handle the increased load. This includes the cooling towers, main transfomer, generator cooling and other systems.

Note 3 - Since this modification would only be done if SCR's are required by 2007, only the interest for completing the project 3 years earlier is included in the economic analysis of the option.

Note 4 - Cost of Urea is based on $0.75 per gallon for a 50% liquid solution. Cost of ammonia is for anhydrous at $0.15/lb (Current price for ammonia used for water treatment at IGS).

Note 5 - Operating cost for SNCR includes 1% of the capital cost per year for Maintenance. The Operating cost for SCR includes 2% of the capital cost due to anticipated frequent replacement of catalyst panels.

Note 6 - SO2 emissions will decrease by installation of a device to increase scrubber removal efficiency. The device eliminates the "sneakage" of flue gas around the module walls thus improving removal efficiency.

Note 7 - Capital cost includes and extra $200,00 for minor modifications to main *transformer and isophase duct to handle increased load.*

2/9/2001

IP7_040328

IGS Uprate Project Coordination

Task Name	Projected Cost	2000	2001 – 2004
Unit 2 Projects	**$10,850,000.00**	**01/02/2001**	**04/01/2004**
HP Turbine Retrofit	$4,800,000.00	01/15/2001	04/01/2002
Cooling Tower Performance Upgrade	$2,000,000.00	02/01/2001	04/01/2004
Boiler Safety Valve Addition	$250,000.00	03/01/2001	04/26/2002
Generator Cooling Enhancements	$100,000.00	04/02/2001	04/01/2002
Isophase Cooling Enhancements	$100,000.00	04/02/2001	04/01/2002
Large Motor Bus Loading Equalization	$150,000.00	04/02/2001	04/01/2002
ID Fan Suction Duct Evaluation	$150,000.00	04/02/2001	04/01/2002
Boiler Feed Pump Performance Upgrad	$150,000.00	01/02/2001	04/01/2002
Main Step-up Transformer Cooling	$100,000.00	03/01/2001	04/01/2002
Burner Replacement	$2,000,000.00	03/01/2001	04/01/2002
Scrubber Wall Ring	$600,000.00	05/01/2001	04/01/2003
Generator SCW O2 Monitoring	$100,000.00	04/02/2001	04/01/2002
HP Heater Drain Line Mods	$100,000.00	04/02/2001	04/01/2002
Boiler Modifications	$250,000.00	04/02/2001	04/01/2003
Unit 1 Projects	**$10,850,000.00**	**01/02/2001**	**04/01/2003**
HP Turbine Retrofit	$4,800,000.00	01/15/2001	04/01/2003
Cooling Tower Performance Upgrade	$2,000,000.00	02/01/2001	04/01/2003
Boiler Safety Valve Addition	$250,000.00	03/01/2001	04/01/2003
Generator Cooling Enhancements	$100,000.00	04/02/2001	03/01/2002
Isophase Cooling Enhancements	$100,000.00	04/02/2001	03/01/2002
Large Motor Bus Loading Equalization	$150,000.00	04/02/2001	03/01/2002
ID Fan Suction Duct Evaluation	$150,000.00	04/02/2001	03/01/2002
Boiler Feed Pump Performance Upgrad	$150,000.00	01/02/2001	04/01/2003
Main Step-up Transformer Cooling	$100,000.00	03/01/2001	03/01/2002
Burner Replacement	$2,000,000.00	03/01/2001	04/01/2003
Scrubber Wall Ring	$600,000.00	05/01/2001	04/01/2003
Generator SCW O2 Monitoring	$100,000.00	04/02/2001	03/01/2002
HP Heater Drain Line Mods	$100,000.00	04/02/2001	03/01/2002
Boiler Modifications	$250,000.00	04/02/2001	04/01/2003

Printed: 03/11/2001

Milestone △ Summary
Fixed Delay - - - - Slack . . . . . .

IP7_040329

HP Turbine Dense Pack Modifications
Operating Options and Economic and Environmental Analysis

Option	Description	Unit Operation: Station Max Gross Load	Unit Operation: Station Net Heat Rate (BTU/KWH)	Unit Operation: Station Fuel Consumption (TONS/YEAR)	Economics: Total Capital Cost	Economics: Benefit Per Year	Economics: Payback Period (Years)	Economics: Benefit/Cost Ratio	Environmental: NOx Emissions per Year (Tons)	Environmental: SO2 Emissions per Year (Tons)	Environmental Assesment	Comments
	Current Operation	1750 MW	9500	5,268,249	NA	NA	NA	NA	26109	2984	Current Emissions limits are 0.5 lbs/MBTU of NOx and 0.15 Lbs/MBTU of SO2. Both on rolling 30 day average basis.	Current NOx emissions rate is 0.42 lbs/MBTU and SO2 is 0.048 lbs/MBTU
1	*Maintain the same historical maximum load with improved heat rate.*	⇔ Same	⇩ -214	⇩ -118,536	$9,400,000	$4,267,282	0.96	11.67	⇩ -587	⇩ -67	Operating in this manner should not trigger a New Source Review (NSR) or Prevention of Significant Deterioration (PSD) review.	There should be no change in NOx and SO2 emissions rate. Total tons per year reductions are from decreased coal burn.
2	Maintain the same historical steam flow and increase turbine/generator output. (Note 6)	⇧ 40 MW	⇩ -214	⇔ Same	$9,600,000	$15,137,280	0.28	39.46	⇔ Same	⇔ Same	Since the NOx and SO2 emissions should not change, increasing load should not mandate a NSR or PSD review. May be difficult to prove as it varies from year to year naturally.	There should be no change in NOx and SO2 emissions rate.
3	Install additional plant improvements to increase boiler and other systems capacity. No new NOx control equipment.	⇧ 100 MW	⇩ -214	⇧ 310,224	$21,400,000	$37,843,200	0.43	26.33	⇧ 2854	⇩ -680	Since we will be increasing NOx emissions, it will be difficult to get this approved as a "synthetic minor" change. Some NOx control will most likely be required.	Assumes NOx emissions rate increases to 0.44 lbs/MBTU. SO2 emissions will lower to 0.035 Lbs/MBTU. (Note 5)
4	Install additional plant improvements to increase boiler and other systems capacity. *Install moderate NOx reduction equipment* (Note 7).	⇧ 100 MW	⇩ -214	⇧ 310,224	$36,400,000	$35,784,705	0.87	12.89	⇩ -6362	⇩ -680	Permitting with moderate NOx control should not be difficult and many options *available. More aggressive control* (SCR) will probably not be required by 2008 as originally believed.	*Assumes NOx emissions will lower to 0.3* Lbs/MBTU and SO2 emissions will lower to 0.035 Lbs/MBTU

Item	General Assumptions	
1	Present Value Annuity Factor (P/A, 6.35 %, 20 years):	11.2
2	Hours of equivalent operation/year (8760X 0.9 Cap. Factor):	7884
3	Cost of Fuel ($/Ton):	$36
4	Cost of replacement energy ($/MWH)	$48
5	*Avoided maintenance cost for the station* (Note 1):	$5,304,000
6	High pressure turbine section retrofit:	$9,400,000
7	Cost of additional plant improvements (Note 2):	$12,000,000
8	Cost of moderate NOx control equipment:	$15,000,000
9	*Operating cost per year for SNCR* (Note 4):	$2,058,495
10	Coal BTU/LB	11,800
11	Urea (SNCR Reagent) Utilization per Ton NOx removed (Tons)	1
12	Cost of Urea per Ton (Note 3)	$300

Analysis for Option 1	
Turbine Efficiency Increase (guaranteed by supplier) =	2.25%
Boiler Heat Input Reduction = Proportional to Turbine Efficiency Increase =	2.25%
Net Heat Rate Reduction = 2.25%(9500 BTU/KWH) =BTU/KWH	214
Reduced Fuel = (Heat Rate Reduction)(Station Net Load)(Equiv.Hrs)/(Coal BTU/Lb)(2000 *Lbs/Ton) = (Tons)*	118,536
Benefit per Year = (Reduced Fuel)(Cost of Fuel) = $	$4,267,282
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.96
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs - Avoided Costs) =	11.67

Analysis for Option 2	
Benefit per Year = (Increased Generation)(Equiv. *Hrs.) (Cost of Replacement Energy) = $*	$15,137,280
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.28
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs - Avoided Costs) =	39.46

Analysis for Option 3	
Benefit per Year = (Increased Generation)(Equiv. Hrs.) (Cost of Replacement Energy) = $	$37,843,200
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.43
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs - Avoided Costs) =	26.33
Increased Fuel = (Decreased Heat Rate)(Increased Net Load)(Equiv.Hrs)/(Coal BTU/Lb)(2000 Lbs/Ton) = (Tons)	310,224

Analysis for Option 4	
Benefit per Year = (Increased Generation)(Equiv. Hrs.) (Cost of Replacement Energy) - Operating Cost/Year = $	$35,784,705
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.87
Benefit to Cost Ratio = (Benefit per Year)(PV *Annuity Factor)/(Capital Costs-Avoided Costs) =*	12.89

Notes

Note 1 - Avoided maintenance cost equals the normal overhaul cost for the turbine HP section plus the avoided outage extension of 3 days to refurbish the HP nozzle block.

Note 2 - Cost of additional plant improvements is the projects necessary to increase the capacity of all other plant systems to handle the increased load. This includes the cooling towers, main transfomer, generator cooling and other systems.

Note 3 - Cost of Urea is based on $0.75 per gallon for a 50% liquid solution.

Note 4 - Operating cost for SNCR includes 1% of the capital cost per year for Maintenance.

Note 5 - SO2 emissions will decrease by installation of a device to increase scrubber removal efficiency. The device eliminates the "sneakage" of flue gas around the module walls thus improving removal efficiency.

Note 6 - Capital cost includes and extra $200,00 for minor modifications to main transformer *and isophase duct to handle increased load.*

Note 7 - For this economic analysis, moderate NOx reduction technology is assumed to be Selective Non-Catalytic Reduction (SNCR) because it is well proven. Other technologies such as ultra-low NOx burners will be evaluated before the final decision is made.

DRAFT

02/21/2001

IP7_040330

HP Turbine Dense Pack Modifications
Operating Options and Economic and Environmental Analysis

		Unit Operation			Economics				Environmental			
Option	Description	Station Max Gross Load	Station Net Heat Rate (BTU/KWH)	Station Fuel Consumption (Tons/Year)	Total Capital Cost	Benefit Per Year	Payback Period (Years)	Benefit/Cost Ratio	NOx Emissions per Year (Tons)	SO2 Emissions per Year (Tons)	*Environmental Assessment*	*Comments*
	Current Operation	1750 MW	9500	5,268,249	NA	NA	NA	NA	28109	2984	Current Emissions limits are 0.5 lbs/MBTU of NOx and 0.15 Lbs/MBTU of SO2. Both on rolling 30 day average basis.	Current NOx emissions rate is 0.42 lbs/MBTU and SO2 is 0.048 lbs/MBTU
1	*Maintain the same historical maximum load with improved heat rate.*	↔ Same	↓ -214	↓ -118,536	$9,400,000	$4,267,282	0.96	11.67	↓ -587	↓ -67	*Operating in this manner should not trigger a New Source Review (NSR) or Prevention of Significant Deterioration (PSD) review.*	There should be no change in NOx and SO2 emissions rate. Total tons per year reductions are from decreased coal burn.
2	Maintain the same historical steam flow and increase turbine/generator output. (Note 6)	↑ 40 MW	↓ -214	↔ Same	$9,600,000	$15,137,280	0.28	39.46	↔ Same	↔ Same	Since the NOx and SO2 emissions should not change, increasing load should not mandate a NSR or PSD review. May be difficult to prove as it varies from year to year naturally.	There should be no change in NOx and SO2 emissions rate.
3	Install additional plant improvements to increase boiler and other systems capacity. No new NOx control equipment	↑ 100 MW	↓ -214	↑ 310,224	$21,400,000	$37,843,200	0.43	26.33	↑ 2854	↓ -680	Since we will be increasing NOx emissions, it will be difficult to get this approved as a "synthetic minor" change. Some NOx control will most likely be required.	Assumes NOx emissions rate increases to 0.44 lbs/MBTU. SO2 emissions will lower to 0.035 Lbs/MBTU. (Note 5)
4	Install additional plant improvements to *increase boiler and other systems capacity.* Install moderate NOx reduction equipment (Note 7).	↑ 100 MW	↓ -214	↑ 310,224	$36,400,000	$35,784,705	0.87	12.89	↓ -6362	↓ -680	Permitting with moderate NOx control should not be difficult and many options available. More aggressive control (SCR) will probably not be required by 2008 as originally believed.	Assumes NOx emissions will lower to 0.3 Lbs/MBTU and SO2 emissions will lower to 0.035 Lbs/MBTU

Item	General Assumptions	
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4	Cost of replacement energy ($/MWH)	$48
5	Avoided maintenance cost for the station (Note 1):	$5,304,000
6	High pressure turbine section retrofit:	$9,400,000
7	Cost of additional plant improvements (Note 2):	$12,000,000
8	Cost of moderate NOx control equipment:	$15,000,000
9	Operating cost per year for SNCR (Note 4):	$2,058,495
10	Coal (BTU/LB)	11,800
11	Urea (SNCR Reagent) Utilization per Ton NOx removed (Tons)	1
12	Cost of Urea per Ton (Note 3)	$300

Analysis for Option 1	
Turbine Efficiency Increase (guaranteed by supplier) =	2.25%
Boiler Heat Input Reduction = Proportional to Turbine Efficiency Increase =	2.25%
Net Heat Rate Reduction = 2.25%(9500 BTU/KWH) =BTU/KWH	214
Reduced Fuel = (Heat Rate Reduction)(Station Net Load)(Equiv.Hrs)/(Coal BTU/Lb)(2000 Lbs/Ton) = (Tons)	118,536
Benefit per Year = (Reduced Fuel)(Cost of Fuel) = $	$4,267,282
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.96
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs - Avoided Costs) =	11.67

Analysis for Option 2	
Benefit per Year = (Increased Generation)(Equiv. Hrs.) (Cost of Replacement Energy) = $	$15,137,280
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.28
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs - Avoided Costs) =	39.46

Analysis for Option 3	
Benefit per Year = (Increased Generation)(Equiv. Hrs.) (Cost of Replacement Energy) = $	$37,843,200
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.43
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs - Avoided Costs) =	26.33
Increased Fuel = (Decreased Heat Rate)(Increased Net Load)(Equiv.Hrs)/(Coal BTU/Lb)(2000 Lbs/Ton) = (Tons)	310,224

Analysis for Option 4	
Benefit per Year = (Increased Generation)(Equiv. Hrs.) (Cost of Replacement Energy) - Operating Cost/Year = $	$35,784,705
Payback Period = (Capital Costs - Avoided Costs) /Benefit per Year = Years	0.87
Benefit to Cost Ratio = (Benefit per Year)(PV Annuity Factor)/(Capital Costs-Avoided Costs) =	12.89

Notes

Note 1 - Avoided maintenance cost equals the normal overhaul cost for the turbine HP section plus the avoided outage extension of 3 days to refurbish the HP nozzle block.

Note 2 - Cost of additional plant improvements are the projects necessary to increase the capacity of all other plant systems to handle the increased load. This includes the cooling towers, main transformer, generator cooling and other systems.

Note 3 - Cost of Urea is based on $0.75 per gallon for a 50% liquid solution.

Note 4 - Operating cost for SNCR includes 1% of the capital cost per year for Maintenance.

Note 5 - SO2 emissions will decrease by installation of a device to increase scrubber removal efficiency. The device eliminates the "sneakage" of flue gas around the module walls thus improving removal efficiency.

Note 6 - Capital cost includes an extra $200,000 for minor modifications to main transformer and isophase duct to handle increased load.

Note 7 - For this economic analysis, moderate NOx reduction technology is assumed to be Selective Non-Catalytic Reduction (SNCR) because it is well proven. Other technologies such as ultra-low NOx burners will be evaluated before the final decision is made.

02/26/2001

IP7_040331